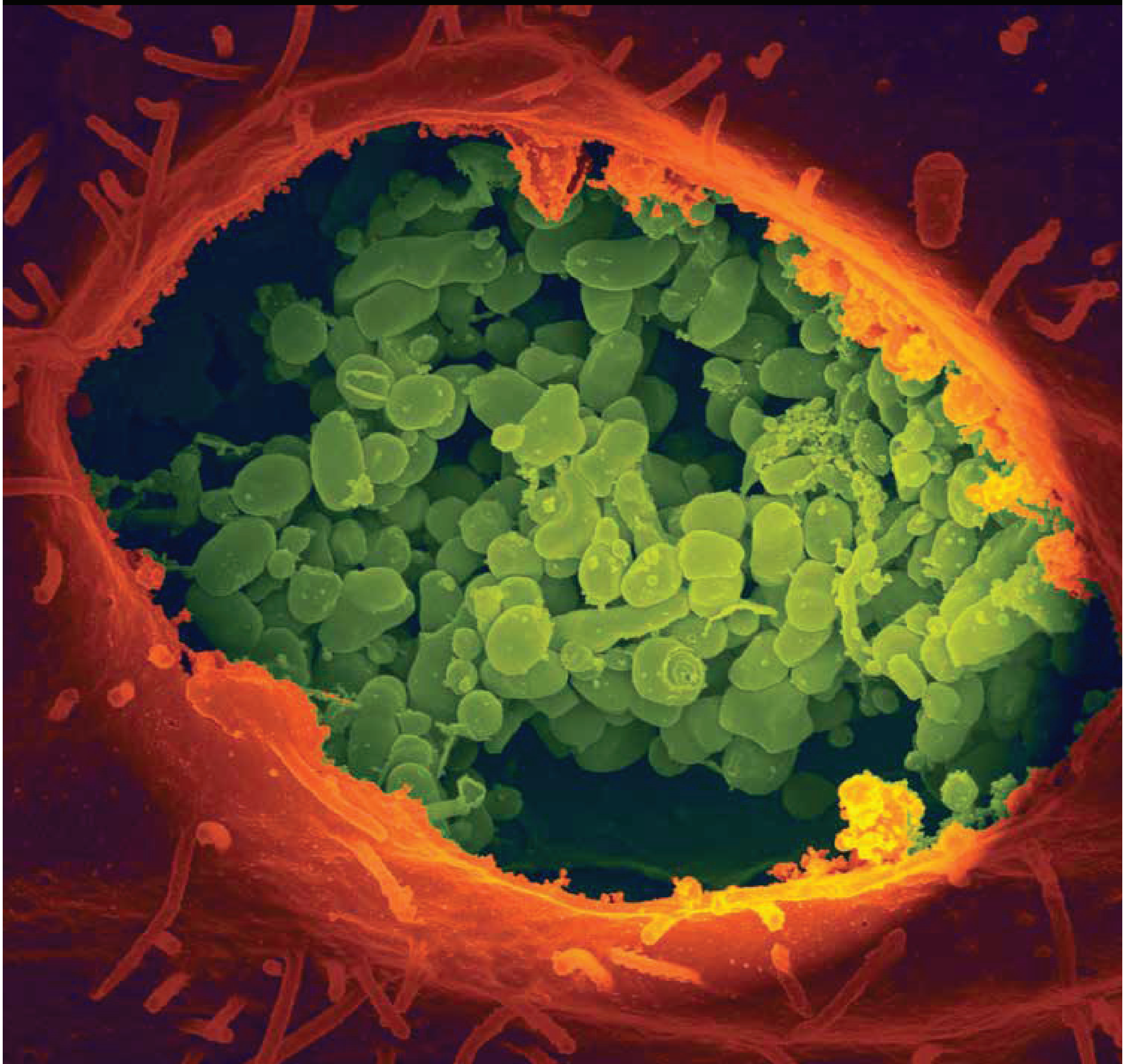

During the 1990s the Japanese cult Aum Shinrikyo unsuccessfully experimented with anthrax, botulinum toxin, cholera, Ebola, and Q fever. (Image of Coxiella burnetti/ National Institute of Allergy and Infectious Diseases)

WMD Terrorism

The Once and Future Threat

By Gary Ackerman and Michelle Jacome

The specter of terrorists and other violent non-state actors acquiring weapons of mass destruction is perhaps an even greater concern than acquisition of weapons of mass destruction (WMD) by states. Given how terrorists periodically target civilians on a large-scale, usually lack a return address, and generally fail to subscribe to traditional notions of deterrence, it is not surprising that terrorists are sometimes portrayed as Bondian supervillians capable of casually constructing doomsday plots. This over-magnification, however, ignores the hurdles inherent in such malignant enterprises. Despite clear interest on the part of some non-state adversaries, a true WMD is at present likely out of their reach in all but a select set of scenarios. Changes in technology, however, could augur a dramatic shift in the WMD terrorism threat picture.

Important Distinctions

Weapons of mass destruction are typically understood to encompass chemical, biological, radiological, and nuclear (CBRN) weapons. Not all CBRN weapons, though, constitute WMD. This distinction is especially important in the case of non-state actors, since such actors often operate under severe resource constraints and are far more likely to plan or implement smaller-scale chemical, biological, or radiological attacks that fall below the WMD threshold. These smaller scale attacks might very well be disruptive and psychologically potent, but would not yield the casualty levels or physical destruction generally associated with a WMD. When we speak of the threat of terrorists and other violent non-state actors (VNSAs) using WMD, we imply CBRN weapons that, if used, would inflict catastrophic casualties, widespread social disruption, or devastating economic consequences beyond those resulting from all but the largest conventional attacks.[1] By this definition, only nuclear weapons are unequivocally WMD; for chemical, biological, and radiological weapons the precise amount, nature, and sophistication of specific attacks determine whether or not they meet the WMD threshold. It is thus important to note the significant differences in use and deployment between chemical, biological, radiological, and nuclear weapons. For example, the motivations

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behind and capabilities required for the use of a nuclear weapon, considered a "low probability, high consequence" event, are wildly different than an attack employing toxic chemicals.[2]

Along these lines, a second salient distinction emerges—between a harm agent and a weapon. A weapon requires the pairing of a harm agent with a delivery system; this can be termed "weaponization." The scale of the harm from toxic chemicals, pathogenic microbes, and ionizing radiation is almost wholly dependent on the efficiency with which the harm agent is delivered to the intended target(s). Delivery systems can range from the decidedly crude (the use of sharpened umbrella points to poke holes in plastic bags filled with sarin nerve agent by the Japanese Aum Shinrikyo cult in 1995) to the extremely sophisticated (the M34 cluster bomb, a U.S. Army munition designed to cover a broad area with sarin). The distinction between agent and weapon is less important in the context of state-level WMD programs since countries rarely invest in the production of a CBRN harm agent without simultaneously developing an effective means of delivery, as seen in the recent parallel development of North Korea's nuclear and intercontinental ballistic missile programs. For non-state actors, the delivery mechanism often presents technical obstacles and resource requirements above and beyond those associated with the harm agent itself. A terrorist might successfully acquire a harmful radioisotope like cesium-137 or a pathogen like *bacillus anthracis*, but this does not necessarily mean that the terrorist can deliver it to a target with enough efficiency to inflict damage meeting the WMD threshold.

Terrorists and other VNSAs attempt to acquire CBRN or WMD capabilities for a number of reasons.[3] Motives might include not only their inherent capacity to inflict massive numbers of casualties, but also such operational objectives as long-term area denial, or the relative ease of covert delivery. The acquisition and use of WMD might also boost the status of the perpetrator, if not among its external constituency, then possibly among intra-organizational and inter-organizational rivals. A non-state actor's ideological or psychological proclivities may drive it to pursue WMD, as was the case of the Aum Shinrikyo cult whose leader, Shoko Asahara, displayed an almost fetishistic affinity for WMD; or Americans Denys Ray Hughes and Thomas Leahy, who were fascinated by poisons of all types. One of the key attractions of CBRN weapons as agents of terror for VNSAs is their dramatic psychological impact on targeted societies, which derives at least partly, from a combination of their intangibility, invasiveness, latent effects (as is the case of many CBR weapons), and unfamiliarity among average citizens.

Harm Agents and Weapons

Despite much hype and fear, there has never been an unequivocal WMD attack by a VNSA. The closest cases include Aum Shinrikyo's dispersal of sarin on the Tokyo subway in March 1995 (that killed 12 and injured more than 1,000), the possible sabotage of the Union Carbide chemical plant in Bhopal, India in 1984 (that led to several thousand deaths from exposure to methyl isocyanate), and a 1996 poisoning by the Khmer Rouge in Cambodia (that led to hundreds of casualties). In all of these cases, there is doubt as to either the intentions of the perpetrators or the number of casualties caused.

The absence of WMD attacks does not mean that VNSAs have not attempted to obtain or use CBRN. The University of Maryland, through its Profiles of Incidents Involving CBRN by Non-state Actors (POICN) Database, has recorded more than 517 cases of pursuit or attempted use of CBRN weapons by VNSAs since 1990, many of which are believed to have been attempts to deploy WMD-scale attacks. The breakdown of agents used or planned for use is depicted in Table 1.[4]

TABLE 1: Agents Used or Planned for Use, 1996–2016.	
Agent Type	**# of Events**
Biological	107
Chemical	400
Radiological	55
Nuclear	18
Total	580*

Source: University of Maryland POICN Database.

*Certain incidents involve more than one agent type, therefore agents used exceeds the total 517 incidents during the timeframe.

While chemical agents have been the preferred weapon of choice of perpetrators, it is important to also examine the dangers posed by nuclear, radiological, and biological agents.

Nuclear

The shortest—not necessarily the easiest—route for a non-state actor to aquire a nuclear weapon is to obtain one from a preexisting state arsenal. The Russian nuclear weapon arsenal, specifically quasi-retired tactical nuclear weapons, demonstrates worrying signs of porosity. However, the most likely source of a complete and intact nuclear weapon is Pakistan. The country is home to some of the most formidable VNSAs in the world and is presently developing smaller, tactical warheads to be forward-deployed near the Indian border.[5] If these tactical nuclear weapons were to enter into widespread service, the warheads would be the most vulnerable on earth given their relative seclusion and portability.[6] That being said, nuclear warheads in state arsenals are among the best protected items on earth. Absent insider access or a rare breakdown of security—e.g. during a coup d'état—VNSAs would find it extraordinarily difficult to acquire and smuggle an intact weapon without detection. VNSAs might therefore judge it easier to obtain fissile material and construct their own weapon. Fabricating their own fissile material from raw products would demand prolonged engagement in either the enrichment of uranium or the chemical separation of plutonium—processes that experts believe to be too complex, costly, and detectable for any currently known terrorist organization to realistically undertake.

This leaves acquisition of weapons-usable or nearly usable material as a more enticing option. Aspiring nuclear actors might target highly enriched uranium used in less secure environments, such as research reactors, isotope generation facilities, or even nuclear maritime propulsion contexts.[7] Such operations will remain potentially vulnerable until they are converted to technologies that require less or eliminate altogether the need for highly enriched uranium. On the other hand, if material is acquired by an insider or other criminal not seeking to use it himself but to sell on the "black market," prospects for interdiction are slightly better as global intelligence and law enforcement have proven themselves adept at setting up "stings" to recover such material.

Radiological

Weaponization of radiological agents is likely to be seen as far less challenging, and therefore more attractive to VNSAs, than acquiring nuclear weapons. Radiological weapons can be deployed using a range of delivery systems, from sophisticated aerosol dispersal systems that present an inhalation hazard to radiation emitting devices that simply hide a piece of radiological material and expose passers by to harmful radiation. Any attack could cause massive disruption and anxiety—but only at the upper end of the scale of possible radiological weapons in both size and complexity would an attack reach the WMD threshold.[8] The psychological effects coupled with the sheer number of radiological sources in circulation represent an attractive option for VNSAs seeking to use CBRN weapons.

Obstacles to the acquisition of radioactive materials by theft are location dependent. The most vulnerable materials are radiological sources housed in portable devices, such as medical mobile irradiators and imaging devices that can be wheeled about.[9] Other potential methods of acquisition include "deliberate transfer by a government, unauthorized transfer by a government official or a facility custodian (insider), looting during coups or other times of political turmoil, licensing fraud, organized crime, exploiting weaknesses in transportation links, sellers of illicitly trafficked radioactive material, and finding orphan radioactive sources (that have been lost, stolen, or fallen outside of regulatory control)."[10] Between 1990 and 2010, there were close to 400 incidents of high-threat radiological materials that fell out of regulatory control. Since 2010 these incidents have doubled.[11] However, it is important to note that there has only been one incident involving a radiological agent since 2012. While material loss is a potential threat, it should not be over-estimated since, according to the data, it does not often fall into the hands of terrorists who want to use it as a radiological weapon.

In any event, if acquisition did occur, a VNSA would need to overcome challenges related to the safe handling of radioactive materials, and have the knowledge to identify the correct amounts and types of explosives for dispersal over a wide area. The VNSA would also need to have the skillset to fabricate the required physical form of the radioactive source to ensure effective dispersal of the material.[12]

Fortunately, powerful radionuclides are fairly easy to detect with passive radiation detection systems, often deployed at ports of entry and international borders. Smuggling such materials, however, may not be necessary for radiological attacks given the likelihood that suitable source material can be found at a facility within the country—if not the immediate vicinity—of the desired target. A VNSA could make the very facility housing the radiological material a target by prefabricating the dispersal device such that it could be loaded and deployed as soon as the material was acquired, or by simply employing explosives to compromise the containment capacity of an industrial irradiation facility or nuclear spent fuel pool. In spite of the apparent viability of some of these tactics, radiological attacks are not common because of their lack of outright lethality and visceral violence as compared to the alternatives, and may not be worth the operational risks and degree of retributive response such an operation is likely to incur.

Chemical

In the event that a VNSA pursues a ready-made chemical weapon, it might do so through theft or state sponsorship. The most likely sources are the stockpiles of such unstable states as Syria, Iraq, Libya, and North Korea. While international retribution against these states discourages their deliberate provision of chemical weapons to VNSAs, there might be willing collaborators with access to these materials within such states. Unstable states might also lose control of these weapons, as has been reported in the case of Syria and Iraq, where the Islamic State of Iraq and the Levant (ISIL) allegedly gained access to weapons stockpiles of the Syrian and former Iraqi regimes.[13]

A second option is to produce a chemical agent and appropriate delivery mechanism using precursor materials. The simplest types of chemical weapons involve the release of highly volatile or gaseous common chemicals, for example chlorine gas or hydrogen cyanide, which can easily be produced by individuals with a high-school level of training.[14] Therefore, since certain toxic chemicals can be produced in weapons-usable quantities with less specialized equipment than is needed for other agents (chlorine is one example), it is no surprise that small-to medium-scale chemical attacks have been the most common CBRN weapon type utilized by VNSAs. However, breaching the WMD threshold would require considerable volumes of these types of agent.

A third, fairly straightforward yet appreciably more alarming chemical attack scenario is the release of toxic industrial chemicals from storage or during transportation. The sources for these potentially crude weapons often exist in large quantities in poorly secured facilities near populated areas and provide attractive targets for terrorists and other VNSAs.

The final option is the production by terrorists of highly toxic, traditional chemical warfare agents. Since 2014, there have been a few examples of such attacks by ISIL using sulfur mustard agents against Kurdish fighters.[15] Nerve agents, such as tabun, sarin, and VX, however, require a more advanced level of training to ensure safety during the manufacturing process and maximum effectiveness of deployment.[16] However, many complex chemicals that can serve as weapons are used for licit applications (e.g pharmaceuticals with high toxicity), are increasingly being synthesized in developing countries, and are becoming readily available for purchase. For example, Chinese pharmaceutical producers are illicitly shipping sufficient amounts of Carfentanil to potentially deliver tens of millions of lethal doses across the globe. While efficient delivery of such an agent is no mean feat for a VNSA, such quantities of these deadly agents could still kill or injure hundreds or even thousands if deployed in confined spaces.

Biological

Biological attacks have the potential for the most catastrophic effects outside of nuclear weapons, but there are significant difficulties associated with attacks using living weapons. Aum Shinrikyo experimented with anthrax, botulinum toxin, cholera, Q fever, and even ebola, from 1990–95, but was unsuccessful due to unsophisticated delivery mechanisms and nonvirulent strains.[17] The mechanism through which the lone actor Bruce Ivins chose to disperse anthrax-causing spores—a letter—was also unsophisticated and, fortunately, although his expertise and access allowed him to produce a sophisticated agent, it was not dispersed at a catastrophic scale.

The pathways to acquisition of a biological weapon include theft (most likely from a state-run program) or in-house production.[18] Similar to other agents, there is concern that insiders or individuals with access to state-run programs could potentially provide a VNSA with a highly lethal, highly contagious agent. The potential to divert biological weapons and materials is particularly strong in countries with a history of bioweapon programs, where many sites are vulnerable to diversion, insider collaboration, or theft.[19] Additionally, there are more than 1,500 state-owned and commercial culture collections intended for research that might be sources of biological pathogen seed stocks. In-house manufacture and production of these agents entails multiple complications for a VNSA. Obtaining the correct micro-organism, procuring the right equipment, avoiding contamination, and ensuring virulence during weaponization are only a few of the obstacles to a successful attack. Given these complications, the most common types of biological weapons have been simple toxins like ricin. VNSAs have been successful in extracting this agent from castor plant beans as illustrated in some jihadist manuals and online videos. However, even though these toxins are produced by living organisms, they are neither infectious nor contagious, thus limiting their mass-casualty potential.

At present, there is no evidence of a successful mass-casualty attack by a VNSA with a contagious bio-agent, and according to POICN there have been only 11 small-scale incidents involving biological agents since 2012. This could be because even if a VNSA was able to obtain a biological agent and properly transport or smuggle it to the target, it would still need to ensure pathogenicity and virulence of the microbe, maintain pathogen stability, accurately calculate the necessary infectious dose, achieve optimal composition formulation, prevent incremental degradation while transporting, and be able to assess difficult to control environmental factors during delivery.[20]

Ambitions and Capabilities

Given the variety of motives for employment of these weapons, we should not be surprised that VNSAs of different ideological persuasions have sought WMD capability. Incidents involving VNSA use of CBRN materials intended for WMD attacks have progressively become more complex and sophisticated.[21] This, coupled with the expressed intention of some actors to seek WMD both for their physical and psychological effects, suggests that the threat of VNSA WMD attacks is not decreasing.

In answering the question of who and what should be the focus of concern, we observe in Figure 1 that, of the total number of incidents in POICN, 31 percent are attributed to extremist religious actors (including lone actors/autonomous cells in support of a collective religious ideology), 22 percent to ethno-nationalist actors (including lone actors/autonomous cells that expressed motivation to establish ethno-nationalist sovereignty or bolster ethno-nationalist rights) , and 11 percent to lone actors or autonomous cells espousing idiosyncratic motives.[22] The remaining cases include far-right and left-wing groups, cults, single-issue groups, and unknown perpetrators.

Since 2012, the distribution of perpetrators changed dramatically from the preceding period. We observe in Figure 2 that an estimated 71 percent of CBRN related incidents are specifically attributed to religious extremists actors including lone actors/autonomous cells in support of a collective religious theology. The second largest set of incidents, with 19 percent, includes lone actors/autonomous cells motivated by professional/personal grudges and financial gain (11 percent), or those that have been linked to ethno-nationalist ideas (8 percent). Given the clear predominance of two specific actor types in the recent threat picture, we will focus the remaining discussion of the current threat on extremist religious actors, in particular ISIL, and lone actors.

Figure 1: CBRN Incidents by Non-State Actors, 1990–2016.

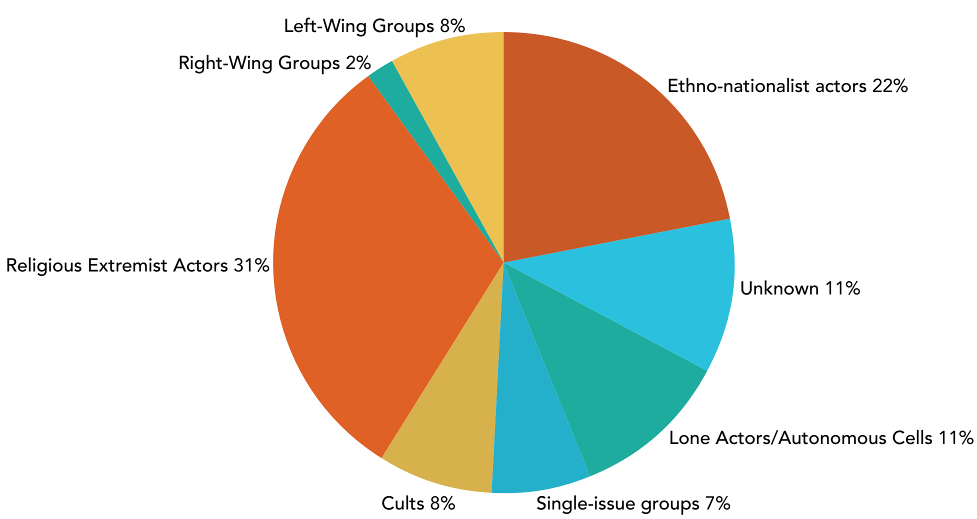
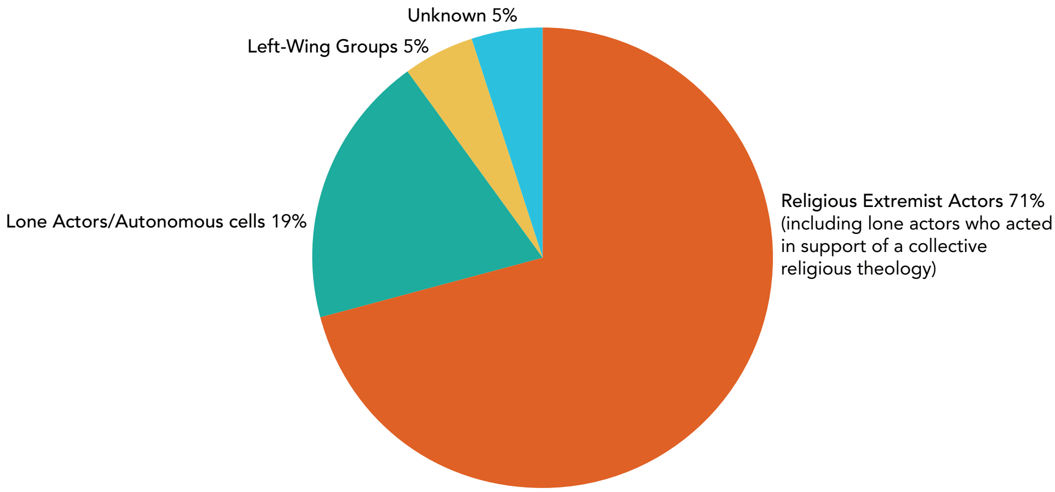


Figure 2: CBRN Incidents by Non-State Actors, 2012–16.



Islamic State

A number of jihadist ideologues have demonstrated their willingness to use indiscriminate, mass-casualty violence, and publicly expressed their interest in conducting CBRN and WMD attacks specifically.[23] American troops operating in Northern Iraq in 2003 discovered primitive labs that the terrorist group Ansar al-Islam had used for experimentation with chemical and toxic weapons. By 2007, the direct forerunners of ISIL, al-Qaeda in Iraq (AQI) and Islamic State of Iraq (ISI), demonstrated their intent to pursue and use chemical weapons on a massive scale by using chlorine to enhance vehicle-borne improvised explosive devises (VBIEDs) in terrorist attacks.[24] In 2014, when ISIL began to contend for territory on a regional scale and was able to seize, purchase, or craft military hardware, they revisited their predecessors' desire to formalize a chemical weapon program. ISIL forces in Syria have deployed chlorine, sulfur mustard, phosphine, and other toxic industrial chemicals such as vinyltrichlorosilane, for tactical purposes—the first chemical warfare agents introduced onto the battlefield since the Iran–Iraq war.[25] It is thus no surprise that media sources routinely mention a growing WMD threat posed by jihadist groups, particularly ISIL.

Fortunately, ISIL as a territorial force has been shattered within the past year; the threat emanating from the group is more localized and the group's capability is considerably reduced. Yet, ISIL recruiters and sympathizers continue to leverage the messaging value of WMD capability. Recently, an ISIL publication claimed the ability to acquire and smuggle a state-built nuclear weapon across the southern border of United States.[26] With the perceived divine right to use WMD intact, and driven by desperation and thirst to avenge the Caliphate, it is possible that ISIL might make a last gasp effort to execute a CBRN attack, or perhaps set the stage for the next group of the Salafi milieu to execute this divine mission in their stead.

Recent studies of ISIL CBRN ambitions and capabilities suggest the most likely form of such threats include sporadic attacks by foreign fighters returning to their countries of origin with the desire to strike at the West.[27] ISIL may have gained access to several dual use-technology sites in Syria and Iraq (especially in pursuit of chemical weapons).[28] Even if these fighters did not succeed in smuggling any purloined materials into the West, it is entirely possible they developed the expertise needed to undertake attacks in their countries of origin, where there might be plenty of poorly-secured precursor chemicals or facilities with other agents available. While the effects of any resulting attacks are likely to remain localized, such attacks are often sufficient to cause mass disruption, if not mass destruction.[29]

Other likely threats include attacks on facilities housing CBRN materials for *in situ* release, or collaboration between ISIL remnants, other VNSAs, and private funders to facilitate the acquisition of CBRN materials or weapons. The utilization of pre-established revenue sources in the black market and through private donors might afford sufficient material support to sustain the group among the community of VNSAs.

Despite these lingering threats from ISIL and the global Salafi jihadist milieu, we have been fortunate that the opportunity, capability, and motives for acquiring and using a WMD have thus far not aligned. In addition, one should not forget about the other jihadist non-state actor—the Shiite militia Hezbollah— which has no current motive to use WMD against the West, but, given their copious resources, global networks and extensive technical assistance from Iran, would be in a much better position than any Sunni jihadist to carry out a WMD attack, should it so choose.

Lone Actors

POICN attributes 18 CBRN incidents—of the total 38 cases recorded since 2012 to lone actors and autonomous cells. Seventy-seven percent of the cases involving lone actors and autonomous cells were driven by either religious or ethno-nationalist motivations. The broad array of actors behind these incidents make it challenging to isolate specific types of threats. Even worse—lone actors and autonomous cell plots are among the most difficult to detect.[30]

For so-called "lone wolf" terrorists, motivations can be driven by a range of less predictable and idiosyncratic factors.[31] They can be shaped by an individual or group's "doctrines, pathologies, and collective or individualistic emotional impulses (including revenge)."[32] Lone actors and autonomous cells often have obscure motives. Many experts have aligned lone actors' incidents with "purely criminal motives," but only 28 percent of incidents recorded in POICN since 2012 were driven purely by criminal motives.[33]

Such actors are typically perceived to have more modest technical capabilities than an organized group, but often have a different set of operational opportunities that could be more advantageous for a WMD attack than those of a larger group. Insider access is one such concern. Technical insiders, with access to source materials, and technical knowledge pose a significant CBRN threat. The ability of law enforcement to detect plots of the lone wolf or autonomous cell nature is limited. For example, shortly after 9/11, Dr. Bruce E. Ivins, a U.S. Army civilian research scientist mailed letters containing a highly virulent and sophisticated form of anthrax to media offices and the offices of two U.S. senators. Five people were killed, 17 people became gravely ill, mail service stopped, and one of the Senate office buildings was shut down for fear of additional attacks.[34] Only five years later did Dr. Ivins became a suspect in the investigation.

Lone actors and autonomous cells have played a prolific role in CBRN terrorism and will continue to do so as long as these weapons continue to have far-reaching impacts driven by fear.[35] A disturbing trend is that terrorist organizations continue to promote insider attacks using CBRN weapons. In 2010, al-Qaeda began promoting and instructing lone actor attacks through its magazine, Inspire.[36] ISIL and other groups invite individuals to become "walk-on terrorists," and provide them with the blueprints for conventional and unconventional weapon attacks.[37] In a manifesto written by Anders Breivek published prior to his attacks in Norway in

2011, he encouraged sympathetic scientists to aid in the development of anthrax, ricin, and liquid nicotine. He may have inspired other, similarly motivated lone actors (particularly of the far-right flavor) to attempt the CBRN attack plots that he ultimately did not.[38]

Lastly, the most likely threat posed by lone actors is a chemical attack. Sixty one percent of CBRN incidents by lone actors and autonomous cells since 2012 used chemical agents. While lone actors and autonomous cells have not yet been able to get a WMD attack "right" in the past, as various technologies change and obstacles to obtaining source materials are overcome (as discussed later), the possibility of a successful WMD attack increases.

Technological Advances and Changing Adversaries

Rapid technological advances are reported in fields as disparate as materials science, pharmaceuticals, communications, automation, biotechnology and robotics on a daily basis. These technological developments could yield new forms of WMD; for example, synthetic biology using techniques such as CRISPR/Cas-9 and commercial "gene fabs" allow for the creation of new variants of existing pathogens or even entirely new pathogens that are designed for resistance to such current countermeasures as antibiotics and vaccines. Toxic, self-replicating nanites that have effects similar to some chemical weapons, are also a plausible, albeit more distant risk.

The most dramatic near-term developments effecting the overall WMD threat picture are, however, likely to relate to the acquisition, production and weaponization of CBRN agents. A variety of technological trends, from miniaturization of manufacturing and turn-key systems to rapid prototyping and marginal cost reproduction—e.g. 3-D printing—could facilitate the production of WMD. In the past, producing sufficient amounts of nerve agent to constitute a chemical WMD required large equipment and dangerous reactants to be set up and monitored by experienced chemical engineers, with a dangerous leak or explosion a constant concern. The advent of new technologies like chemical microreactors (where precursor chemicals are combined under controlled conditions in miniature channels on a "chip") could allow for self-contained production of small quantities of CW in a basement, with almost no hazard and far less vulnerability to detection by authorities. Stringing several of these modules together and operating them for extended periods, could still yield sufficient quantities for the desired level of mayhem. Another

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example is biotechnology "kits" that take much of the technical guesswork out of complex microbiological procedures and are even being marketed to high-schoolers.[39] This phenomenon likely will eventually lead to WMD that can be produced more cheaply, more safely, and with a smaller operational footprint. For terrorists and other VNSAs, such developments will serve only to lengthen Archimedes' proverbial lever when it comes to their asymmetric effects versus their state opponents.

It is not merely the development of new technologies—most terrorists hardly operate at the cutting edge of science—but rather the swift spread of these technologies to commercial-off-the-shelf applications that could boost terrorist capabilities. Once new technologies become available for sale online, they can be purchased and quickly delivered around the globe, effectively resulting in the "democratization" of the means of mass destruction. Moreover, the worry is not just that technological developments are rapidly occurring; the actual rate of change itself is increasing so that the length of time between major breakthroughs is continually decreasing.[40] This makes it difficult for even the most astute observers (including our intelligence agencies) to keep up with technological developments that might impact the threat of WMD terrorism.

Moreover, our adversaries themselves are changing. The arrival of online technical education, typified by the Kahn Academy and numerous MOOCs (massive open online courses), means that radicals in even the most remote, ungoverned regions now have access to at least basic technical knowledge in a variety of disciplines. At the same time, the pervasiveness of social media and other online modalities enables ideologues to reach, and at least sometimes succeed in radicalizing, even the best and the brightest at the most prestigious institutions of higher learning in the West and elsewhere. In this sense, globalization and information technology "are creating more accomplished users."[41] Such dynamics resulting from the information revolution can be expected to move terrorists further up the WMD learning curve, just as technology flattens it out.

The capacity of VNSAs to engage in the complex engineering efforts required to produce and deploy a WMD can be studied through comparative cases. The PIRA's (Provisional Irish Republican Army) in-house mortar program and the FARC's (Revolutionary Armed Forces of Colombia) construction of full-fledged submarines within jungle bases, are examples of how VNSAs are capable of genuinely impressive feats of engineering even under clandestine conditions and external pressure.[42] A willingness and ability to devote substantial resources to the effort for an extended period, the capacity to obtain or develop technical expertise, a safe haven in which to operate, and an organizational culture that embraces learning can lead to success even under the most challenging conditions.

How VNSAs might acquire sophisticated technologies externally, from networks consisting of states, transnational criminal organizations, legitimate commercial enterprises, or other violent groups merits further study. A preliminary model indicates the need to take into account such factors as bargaining, the role of intermediaries, and different loci of transfer. Indeed, several new areas of WMD threat might arise at the nexus between different types of VNSAs. Although, while most transnational criminal organizations (TCOs) might see no profit in assisting terrorists in acquiring or transporting WMD materials, this barrier might not apply in the presence of ideological or kinship ties, where a hybrid TCO–terrorist emerges, or where a criminal organization is infiltrated or duped into unwittingly helping terrorists acquire WMD. FARC's involvement with uranium smuggling, and the development of sophisticated illicit chemical production capabilities among TCOs are just two disturbing examples of such so-called "unholy alliances."[43]

At the conceptual extremity of the confluence of these trends affecting both technology and our adversaries lies the superempowered individual, a single fanatic or misanthrope with the power to upend the entire social system through his or her own actions.[44] While we have not yet seen any unambiguous cases, individuals like Bruce Ivins and Ramzi Yousef come close. This type of individual has the capacity to pose a grave threat, yet, if combined with an intense ideological motivation, might be prone to scales of violence that make them even more likely to select CBRN weapons to conduct a WMD attack than any terrorist organization witnessed thus far.[45]

Most terrorists are decidedly conservative most of the time and imitative in their use of weapons and tactics. It is only a minority that historically has ever pursued unconventional means of harm and an even smaller number that has had even minimal success. The key challenge, from a strategic perspective, is proactively distinguishing the few terrorists and other VNSAs most likely to move successfully through all of the gates associated with adoption of WMD-relevant technology from the vast majority that are not. One of the authors has developed a framework to address this question, the Terrorist Technology Adoption Model (T-TAM), which assesses the relative likelihood of a particular terrorist group (or other VNSA) a) gaining awareness of, b) deciding to pursue, and c) then successfully acquiring a given technology, and has been applied to the technologies underlying WMD. While space limitations preclude a detailed description of the framework, T-TAM examines the interaction between a set of variables characterizing the technology under consideration and those relating to the nature of the actor itself (with particular attention paid to the elements of knowledge transfer), as well as accounting for environmental factors and the prior behavior of other actors in the system.[46]

One of the core insights derived from T-TAM is that a given technology on its own, while theoretically capable of enabling great harm—e.g. if it facilitates the acquisition of a WMD—does not pose a threat until it falls into the hands of a terrorist or other VNSA who both recognize its potential, want to adopt it, and succeed in doing so. It is thus specific terrorist-technology dyads that are of greatest concern, rather than any terrorist group or technology taken on its own. Adopting this approach and utilizing T-TAM can help mitigate the dual-use dilemma. This is so because, on the one hand, even if a given technology hypothetically increases the WMD potential of VNSAs, but only a handful of VNSAs will ever proceed through all of the adoption gates with respect to that technology, then it is more efficient and probably more effective to concentrate our counterterrorism resources on observing those VNSAs for threatening behavior. On the other hand, a technology that is likely to be sought after and easily adopted by a substantial portion of VNSAs presents more of a dual-use problem and might be a good candidate for some type of technology control or monitoring regime.

One less comforting finding from T-TAM is the key role played by demonstration in spurring the diffusion of a given weapon. Once one terrorist or other VNSA succeeds in launching a successful WMD attack, even if by chance, this can be a catalyst for future attacks by others in that it reduces the uncertainty surrounding such an enterprise by showing that it can indeed be accomplished by a non-state actor. This has been illustrated recently outside of the WMD realm with the rapid adoption by several jihadist terrorist organizations of the use of UAVs as attack platforms.

Conclusion

Some of the hype surrounding WMD terrorism is overblown. Despite clear interest on the part of our most vehement and capable adversaries, a true WMD is likely out of their reach in all but a few scenarios: the release of *in situ* toxic industrial chemicals or highly radiological materials close to an urban area (only possible in a limited number of locations), and the highly unlikely serendipitous acquisition of a viable nuclear or biological weapon from a state arsenal. The good news from a strategic perspective is that these scenarios are preventable with current security and non-proliferation approaches (provided they continue to be implemented effectively), and there is still a window (albeit a shrinking one) to bring our collective talents and resources to bear on limiting the increased WMD terrorist threats of tomorrow. Some of the same dynamics increasing the threat might also yield new ways to defend against it. For instance, synthetic biology might produce new antiviral treatments or antibiotics; better manufacturing techniques might allow for more sensitive radiation detectors; and more widespread education might reduce the number of disaffected youth in the developing world.

When considering the threat of WMD terrorism, we thus come around to the age-old strategic race between the offense and the defense, so ably evinced by Hugh Turney-High: "[t]he offense thinks up new weapons or improves the old ones so that the defence's genius must think up new defence or be crushed out of existence. There is nothing new nor old in this."[47] Except that in this case, technologies seem to favor the adversary, the growing empowerment of the individual is unlikely to be reversed, and there are a number of tipping points—such as the first demonstration by a terrorist of a WMD capability—that could profoundly alter the system. It thus appears that the VNSA offense in future will be playing with a stronger hand than the international security defense—and with the stakes as high as with WMD, the defense cannot afford to falter even once. PRISM

Notes

[1] For a detailed discussion and justification of this definition, see Gary Ackerman and Jeremy Tamsett, "Introduction," in Gary Ackerman and Jeremy Tamsett (eds.), *Jihadists and Weapons of Mass Destruction*, Boca Raton, Florida: CRC Press (2009), xix–xxii. For alternative defintions, see the extended discussion in W. Seth Carus, Defining '*Weapons of Mass Destruction*,' Center for the Study of Weapons of Mass Destruction Occasional Paper 4, National Defense UniversityPress, Washington, DC, February 2006.

[2] Gary Ackerman and Jeremy Tamsett, "Introduction," xxi.

[3] Victor H. Asal, Gary A. Ackerman, and R. Karl Rethemeyer (2012): "Connections Can Be Toxic: Terrorist Organizational Factors and the Pursuit of CBRN Weapons," *Studies in Conflict & Terrorism*, 35:3, 231.

[4] Gary Ackerman and Markus K. Binder. "Pick Your POICN: Introducing the Profiles of Incidents involving CBRN and Non-state Actors (POICN) Database," College Park, MD: START, 2017.

[5] Monika Chansoria, "Paksitan's Tactical Nukes Threaten Stability in South Asia," May 5, 2014, *Foreign Policy*, http://foreignpolicy.com/2014/05/05/pakistans-tactical-nukes-threaten-stability-in-south-asia/.

[6] James Halverson, "Radiological and Nuclear Material Vulnerability: An Overview Assessment," Report to NSDD. College Park, MD: START, 2017.16.

[7] James Halverson, "Radiological and Nuclear Material Vulnerability: An Overview Assessment," 32.

[8] Charles D. Ferguson, "Radiological Weapons and Jihadist Terrorism," in *Jihadists and Weapons of Mass Destruction*, 174.

[9] *Nuclear Nonproliferation: Additional Actions Needed to Increase the Security of U.S. Industrial Radiological Sources*," GAO, 2014, 24–25.

[10] For a fuller treatment of this pathway analysis, see Charles D. Ferguson and William C. Potter with Amy Sands, Leonard Spector, and Fred L. Wehling, *The Four Faces of Nuclear Terrorism* (New York: Routledge, 2005), 271–278; and Charles D. Ferguson, "Radiological Weapons and Jihadist Terrorism," 174.

[11] Gary Ackerman, Cory Davenport, Varun Piplani and James Halverson. "Trend Analysis of the RN Materials Out of Regulatory Control (MORC) Database." Final Report to NSDD. College Park, MD: START, 2017.

[12] Charles D. Ferguson, "Radiological Weapons and Jihadist Terrorism," 174.

[13] Herbert Tinsley, Jillian Quigley, Markus Binder, and Lauren Samuelsen. "IS Chemical and Biological Weapons Behavioral Profile," College Park, MD: START, 2017.

[14] Stephanie Meulenbelt and Maarten S. Nieuwenhuizen, "Non-State Actors' Pursuit of CBRN Weapons: From Motivation to Potential Humanitarian Consequences," *International Review of the Red Cross*, 2015, Vol 97: 899, 848.

[15] Associated Press, "Islamic State Used Chemical Weapons against Peshmerga, Kurds Say," *The Guardian*, 14 March 2015. https://www.theguardian.com/world/2015/mar/14/islamic-state-isisused-chemical-weapons-peshmerga-kurds, and BBC News, "Islamic State 'Used MustardGas' against Peshmerga", BBC News, 7 October 2015. https://www.bbc.com/news/world-middle-east-34471237.

[16] Stephanie Meulenbelt and Maarten S. Nieuwenhuizen, "Non-State actors' Pursuit of CBRN Weapons: From Motivation to Potential Humanitarian Consequences," 899, 848.

[17] Cheryl Loeb, "Jihadist and Biological and Toxin Weapons" in *Jihadists and Weapons of Mass Destruction*, 153.

[18] Cheryl Loeb, "Jihadist and Biological and Toxin Weapons," 153.

[19] Jonathan Tucker, "Preventing the Misuse of Pathogens: The Need for Global Biosecurity Standards," *Arms Control Today*, June 2013, http://www.armscontrol.org/act/2003_06/tucker_june03.asp#notes.

[20] Cheryl Loeb, "Jihadist and Biological and Toxin Weapons," 153.

[21] The proportion of cases that are judged to be of high concern in POICN has increased from 47% before 2011 to 70% since 2011.

[22] "Profiles of Incidents Involving CBRN by Non-state Actors (POICN) Database Version 2.53," (June 2017), National Consortium for the Study of Terrorism and Responses to Terrorism (START).

[23] Since 1998, when Osama bin Laden first said that "acquiring WMD for the defense of Muslims is a religious duty," jihadist groups have continually explored the possibility of conducting a mass-casualty CBRN terrorist attack (Osama bin Laden, "Osama bin Laden Interview," interview by John Miller, ABC News, (1998), excerpt accessed November 29, 2017, http://www.pbs.org/wgbh/pages/frontline/shows/binladen/who/edicts.html). A few years later Saikh Nasir bin Hamid al-Fahd issued a fatwa entitled "*A Treatise on the Legal Satus of Using Weapons of Mass Destruction Against Infidels*" that asserted Muslims have the right to kill as many as four million Americans and suggested the use of WMD attacks to accomplish this. Most recently, and later in name of ISIL, Abu Bakr al-Baghdadi, urged Muslims to make a hijra to the Caliphate: "We make a special call to the scholars . . . medical doctors, and engineers of all different specializations and fields" ("The Return of the Khilafah," Dabiq 1 (2014): 11).

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[26] Herbert Tinsley and James Halverson, *Islamic State CBRN Capabilities: An Assessment of Threats and Realities*," College Park, MD: START, 2017.

[27] Herbert Tinsley, et. al., "IS Chemical and Biological Weapons Behavioral Profile".

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[29] For example in the 1995 Tokyo subway attacks by Aum Shinrikyo, 5,510 potential casualties reported to medical facilities, despite not showing any symptoms of nerve agent exposure. 4,400 of these victims were classified as "worried well" and discharged. See A. E. Smithson and L. A. Levy, *Ataxia: The Chemical and Biological Terrorism Threat and the U.S. Response*, Henry L. Stimson Center, October, 2000, Report no. 35.

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[32] James Halverson and Gary Ackerman. *Radiological/Nuclear (RN) Terrorism: Global Assessment of Threat Intention Drivers*, College Park, MD: START, 2015, 3, and Jeffrey M. Bale, "Jihadist Ideology and Strategy and the Possible Employment of WMD," 7.

[33] Victor H. Asal and R. Karl Rethemeyer, "Islamist Use and Pursuit of CBRN Terrorism," in *Jihadists and Weapons of Mass Destruction*, 342.

[34] Deborah Tedford, "Scientist in Anthrax Case Dead of Apparent Suicide," NPR, August 1, 2008, https://www.npr.org/templates/story/story.php?storyId=93161970.

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[41] Gary Ackerman and Lauren E Pinson, "Gauging the Threat," 3.

[42] Gary A. Ackerman, "Comparative Analysis of VNSA Complex Engineering Efforts," *Journal of Strategic Security* 9, no.1 (Spring 2016), 119.

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[46] See Gary A. Ackerman, *More Bang for the Buck: Examining the Determinants of Terrorist Adoption of New Weapons Technologies*, Unpublished Doctoral Dissertation, King's College London (2013).

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